

# Wind Energy

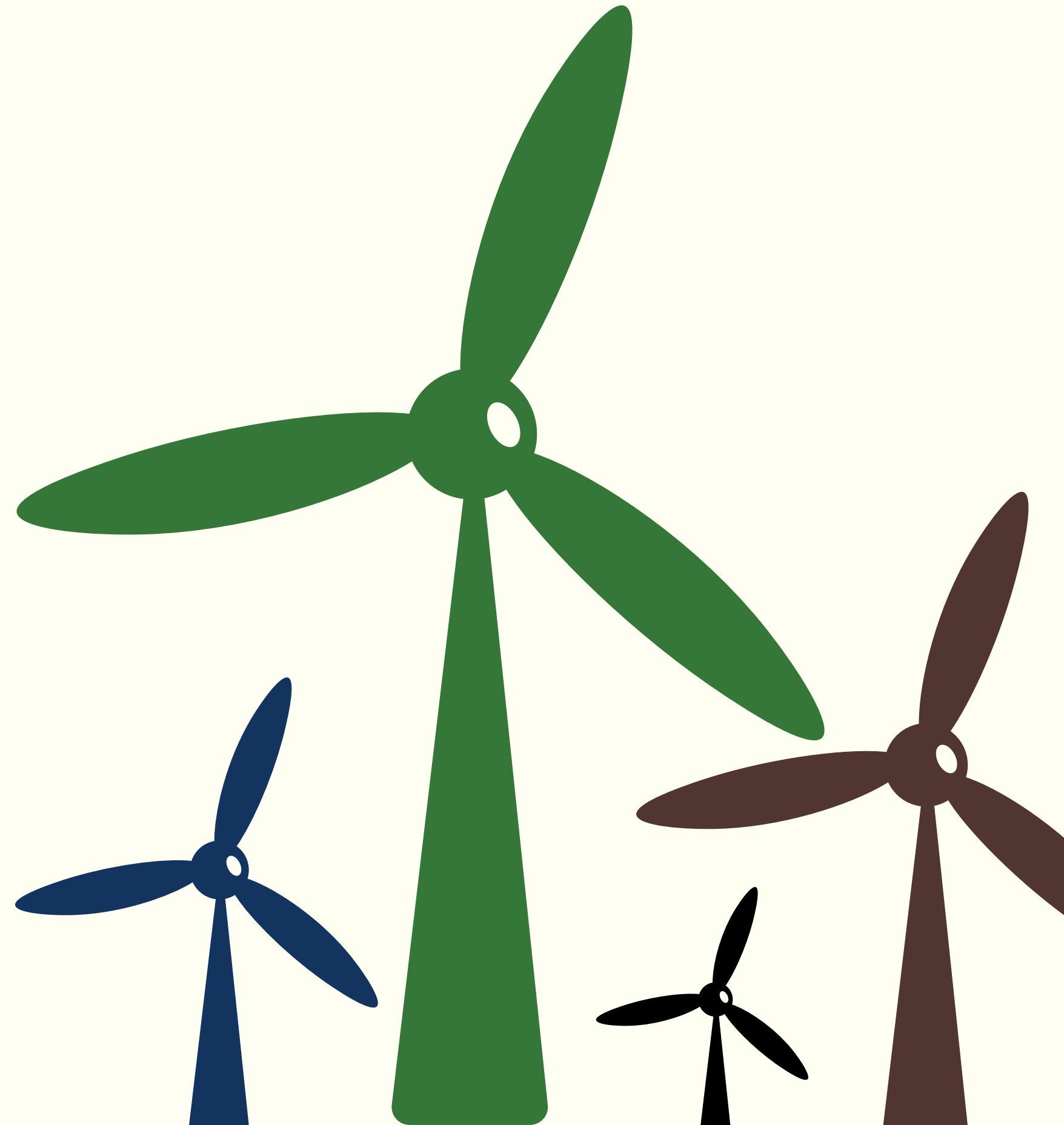
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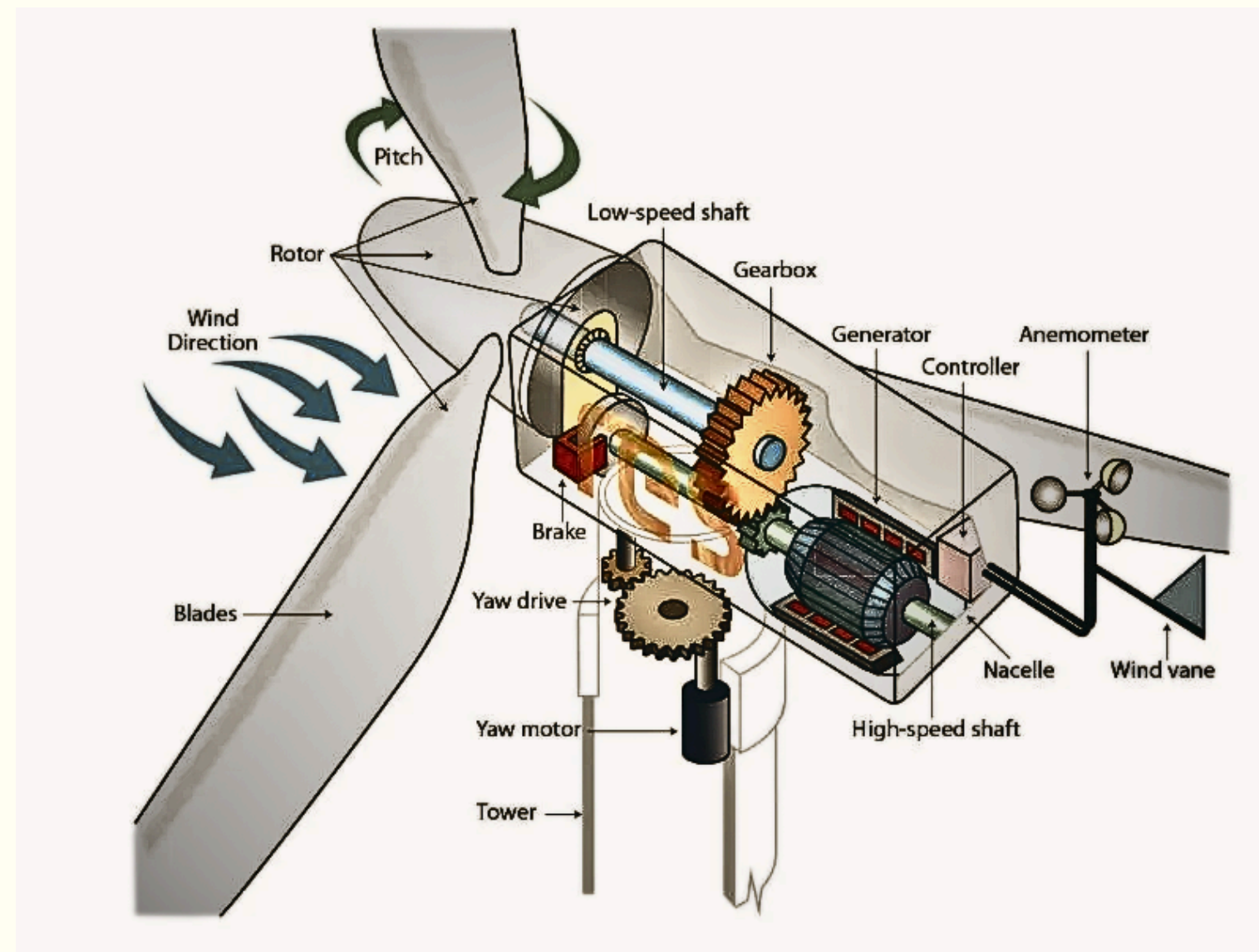
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# HOW IT WORKS ?

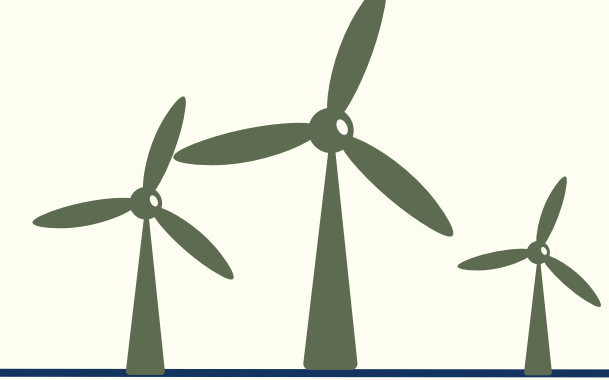
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- In modern wind turbines, wind turns the rotor blades, converting kinetic energy into rotational energy. This energy is then transferred through a shaft to the generator, producing electrical energy.



## WORKING PRINCIPLE

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- Wind energy is the kinetic energy of moving air. The kinetic energy of a mass  $m$  with the velocity  $v$  is  $E_{\text{kin}} = \frac{1}{2} m v^2$
- The air mass ' $m$ ' can be determined from the air density ' $\rho$ ' and the air volume ' $V$ ' according to  $m = \rho V$
- Power is energy divided by time. We consider a small time,  $\Delta t$ , in which the air particles travel a distance  $s = v\Delta t$  to flow through. We multiply the distance with the rotor area of the wind turbine,  $A$ , resulting in a volume of

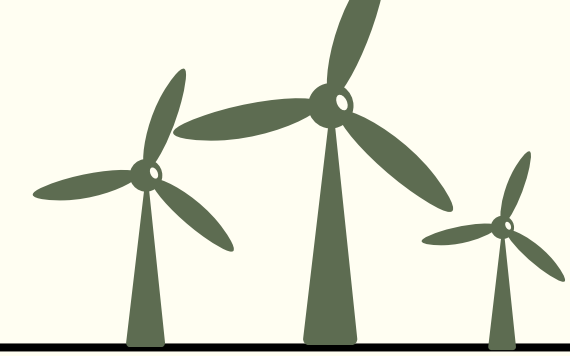
$$\Delta V = A v \Delta t$$

which drives the wind turbine for the small period of time. Then the wind power is given as

$$P_{\text{wind}} = \frac{E_{\text{kin, wind}}}{\Delta t} = \frac{\Delta V \rho v^2}{2 \Delta t} = \frac{\rho A v^3}{2}$$

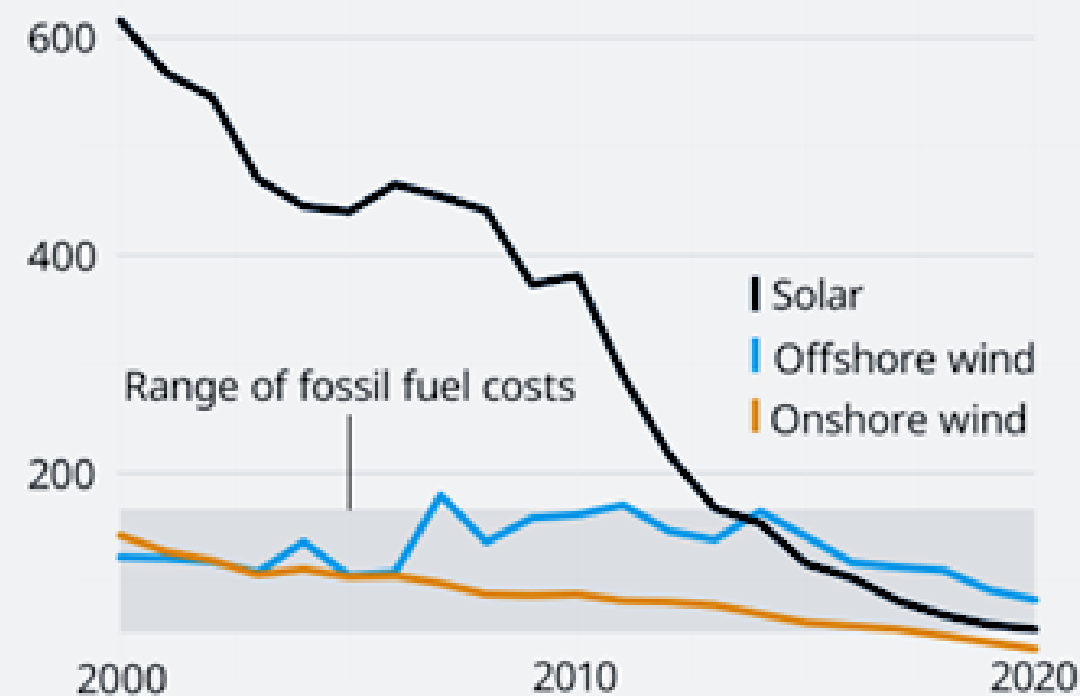
# WIND ENERGY v/s CONVENTIONAL FUEL

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## Solar and wind power have grown cheaper than fossil fuels

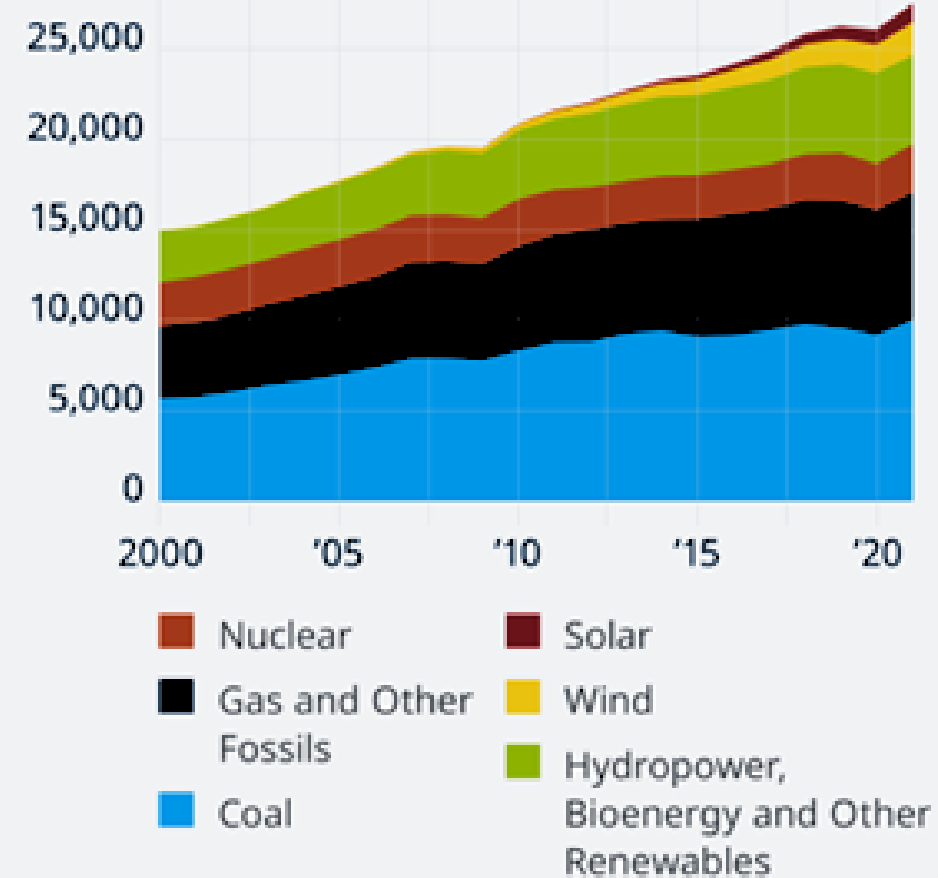
Levelized cost of energy in 2020 USD/MWh



Source: IPCC AR6 2022, IRENA 2022

## Clean electricity is growing, but so is coal and gas

Terawatt Hours of electricity generated



Source: Ember 2022

## The Falling Cost of Renewable Energy

Price per megawatt hour of electricity, by source\*



\* Global weighted average of levelized costs of energy (LCOE), without subsidies.  
Source: OurWorldinData.org

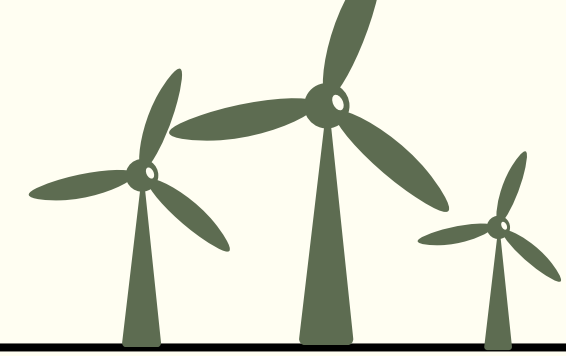


statista

<https://shorturl.at/wxS27>

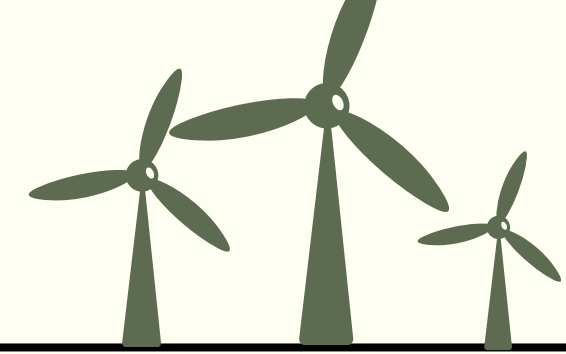
# CHALLENGES

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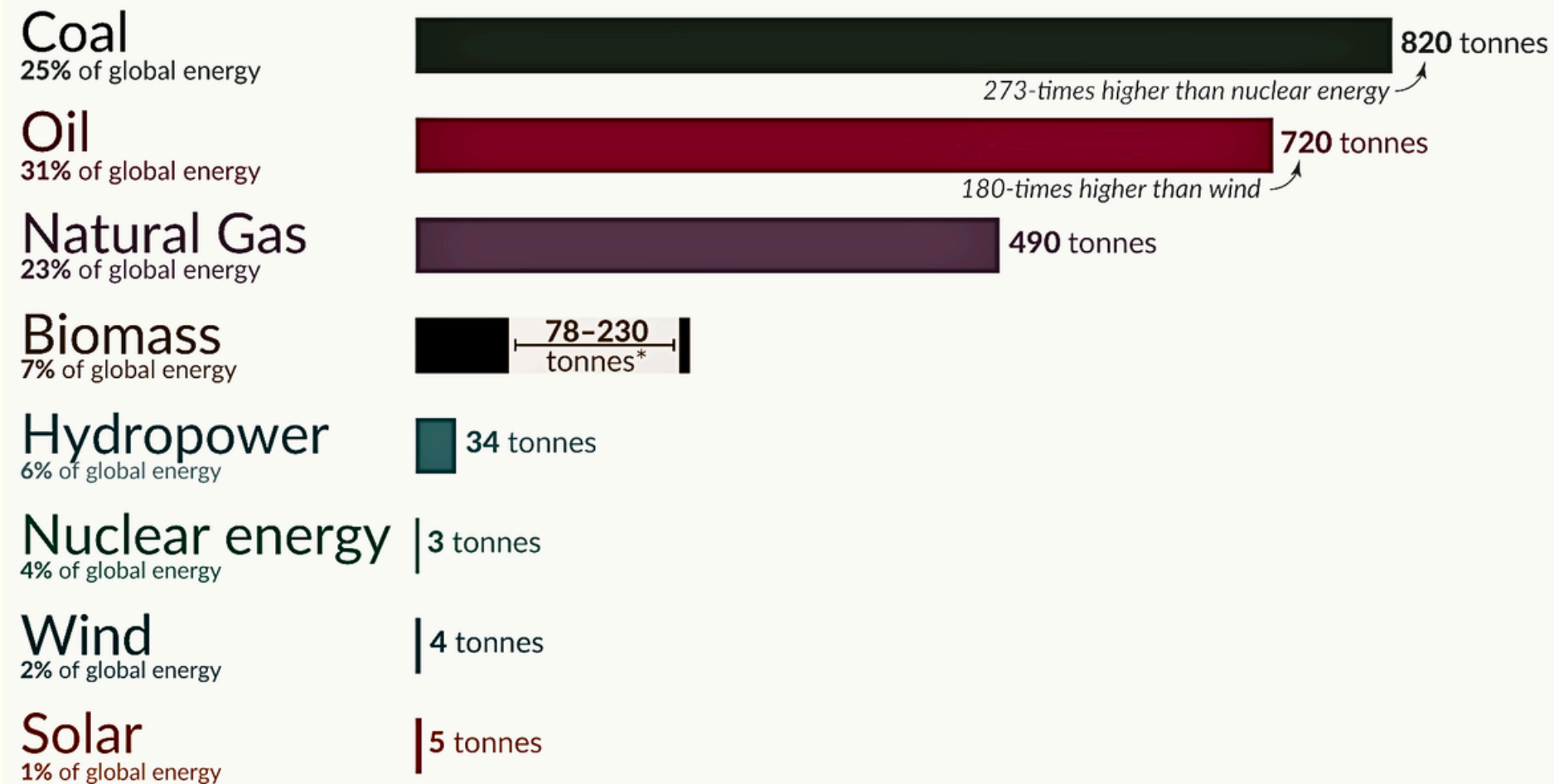
- **Location and Land Use:** Wind turbines require specific wind conditions to operate efficiently, which limits suitable locations for wind farms. Additionally, the construction of wind farms can impact land use and local ecosystems.
- **Intermittency and Variability:** Wind is an intermittent and variable energy source, meaning it is not always available or consistent. This variability can make it challenging to integrate wind energy into the grid and ensure a stable power supply.
- **Offshore Development Challenges:** Offshore wind farms have the potential to generate large amounts of energy close to densely populated areas. However, offshore development presents unique challenges, such as harsh marine environments, deeper water depths, and increased installation and maintenance costs.





## Greenhouse gas emissions

Measured in emissions of CO<sub>2</sub>-equivalents per gigawatt-hour of electricity over the lifecycle of the power plant. 1 gigawatt-hour is the annual electricity consumption of 160 people in the EU.

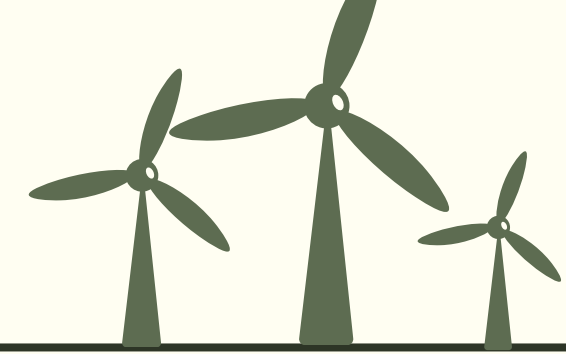


- By replacing fossil fuel-based power plants, wind energy helps improve air quality by reducing emissions of pollutants such as sulfur dioxide, nitrogen oxides, and particulate matter
- Wind energy does not produce toxic pollution which is beneficial for public health.

- Wind farms utilize land for installation, but the surrounding areas can often be used for agriculture or other purposes. Moreover, wind energy has a lower impact on biodiversity compared to fossil fuel extraction

# INDIAN PERSPECTIVE

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Wind energy in India:

Total installed capacity  
**39.25 GW** Mar 2021

**GISSCORE**  
**Datastory**

Wind Energy is  
**41.5%**  
of total RE capacity

2022 **05 GW**

2030 **30 GW**

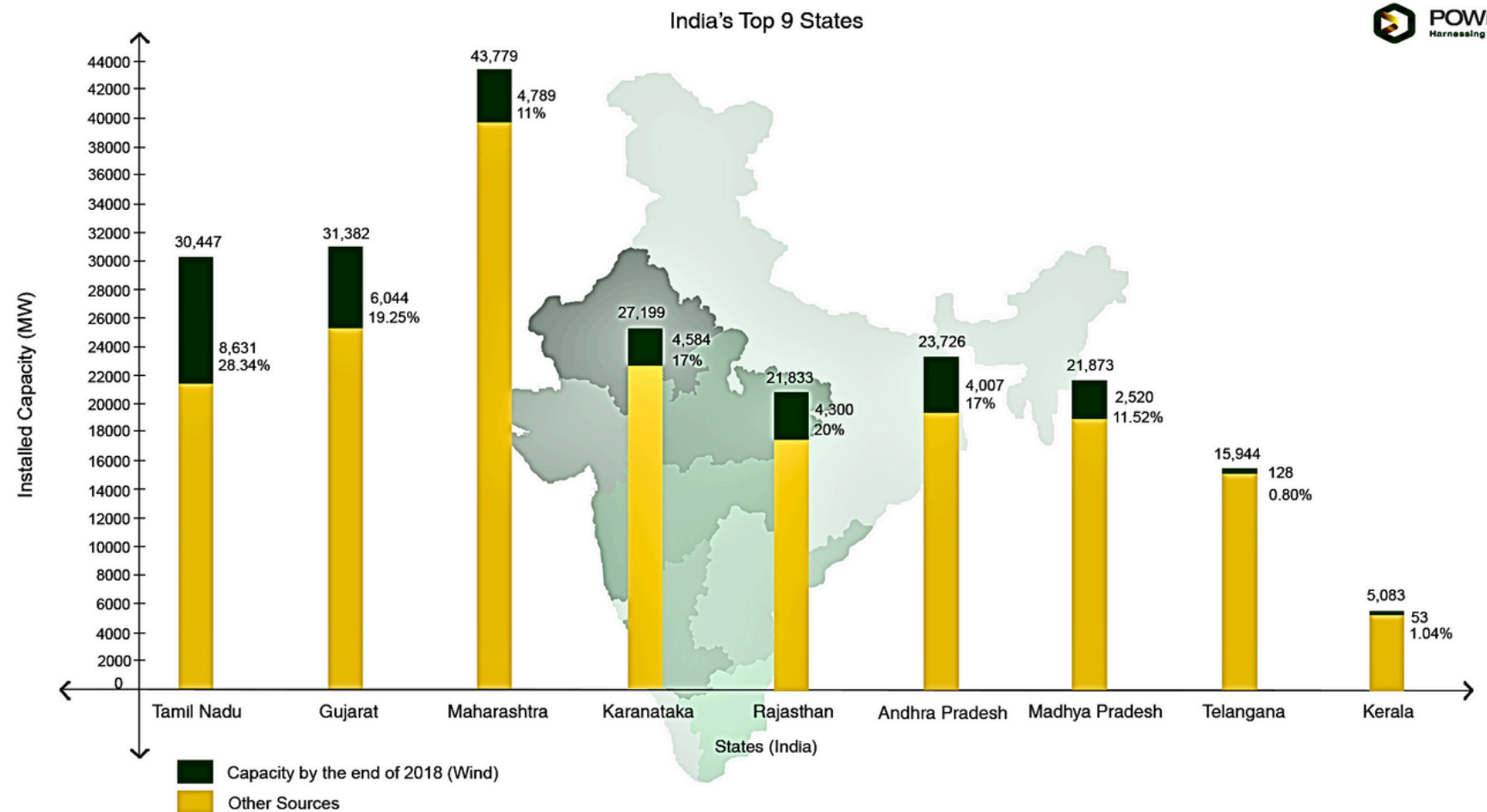
Top five countries with  
the highest wind energy  
capacity in 2020:

|         |           |
|---------|-----------|
| China   | 288.32 GW |
| US      | 122.32 GW |
| Germany | 62.85 GW  |
| India   | 38.63 GW  |
| Spain   | 27.24 GW  |

**Wind Energy in India**

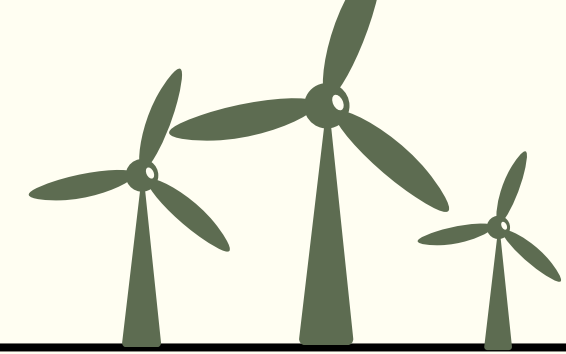
Top states in wind energy  
capacity in 2020-21

|             |       |
|-------------|-------|
| Tamil Nadu  | 9.6GW |
| Gujarat     | 8.5GW |
| Maharashtra | 5GW   |
| Karnataka   | 4.9GW |
| Rajasthan   | 4.3GW |

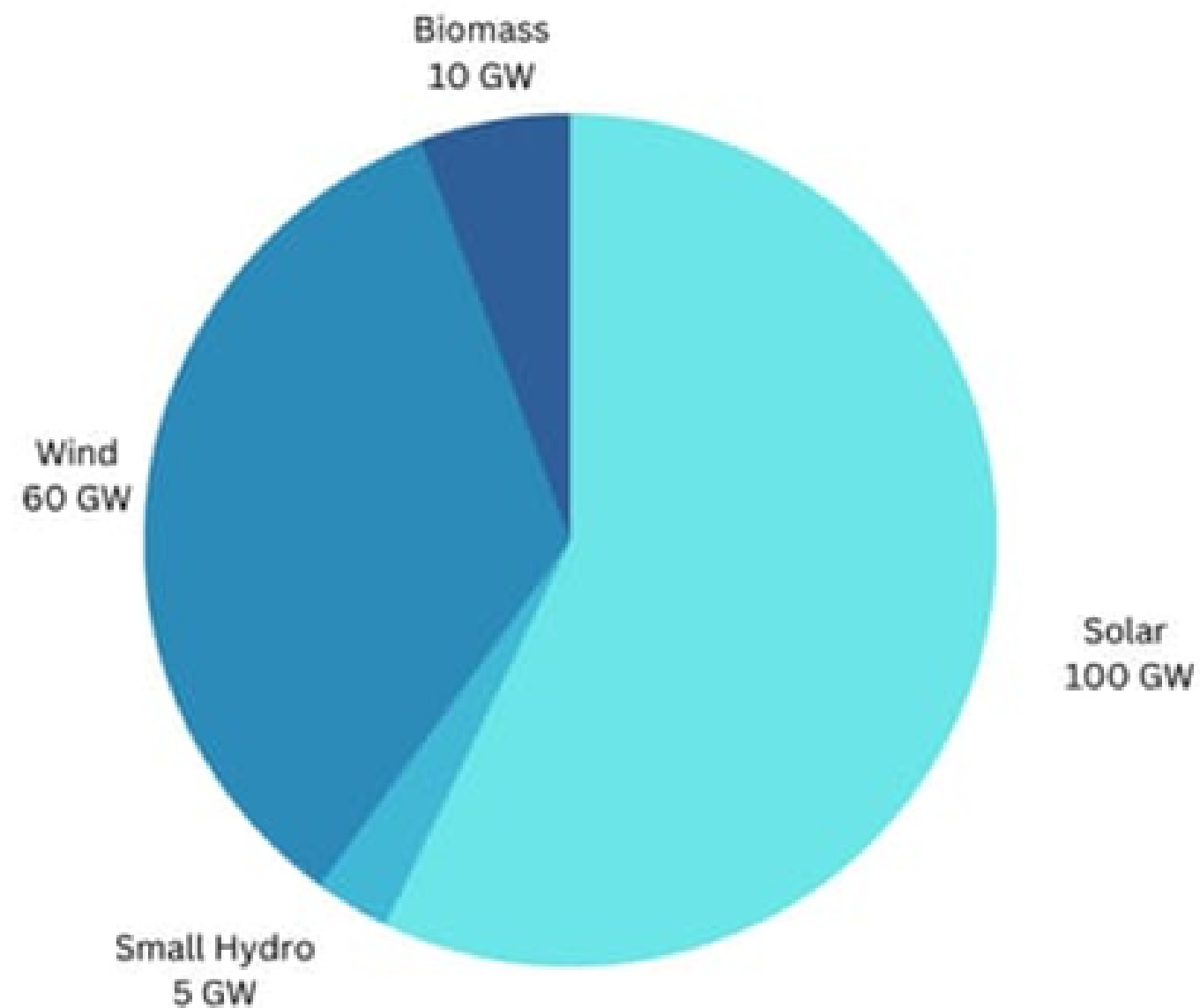


<https://iasscore.in/data-story>

<https://powercon.in/wp-content/uploads/2019/04/Data02.png>



Renewable energy targets of India to be achieved by 2022

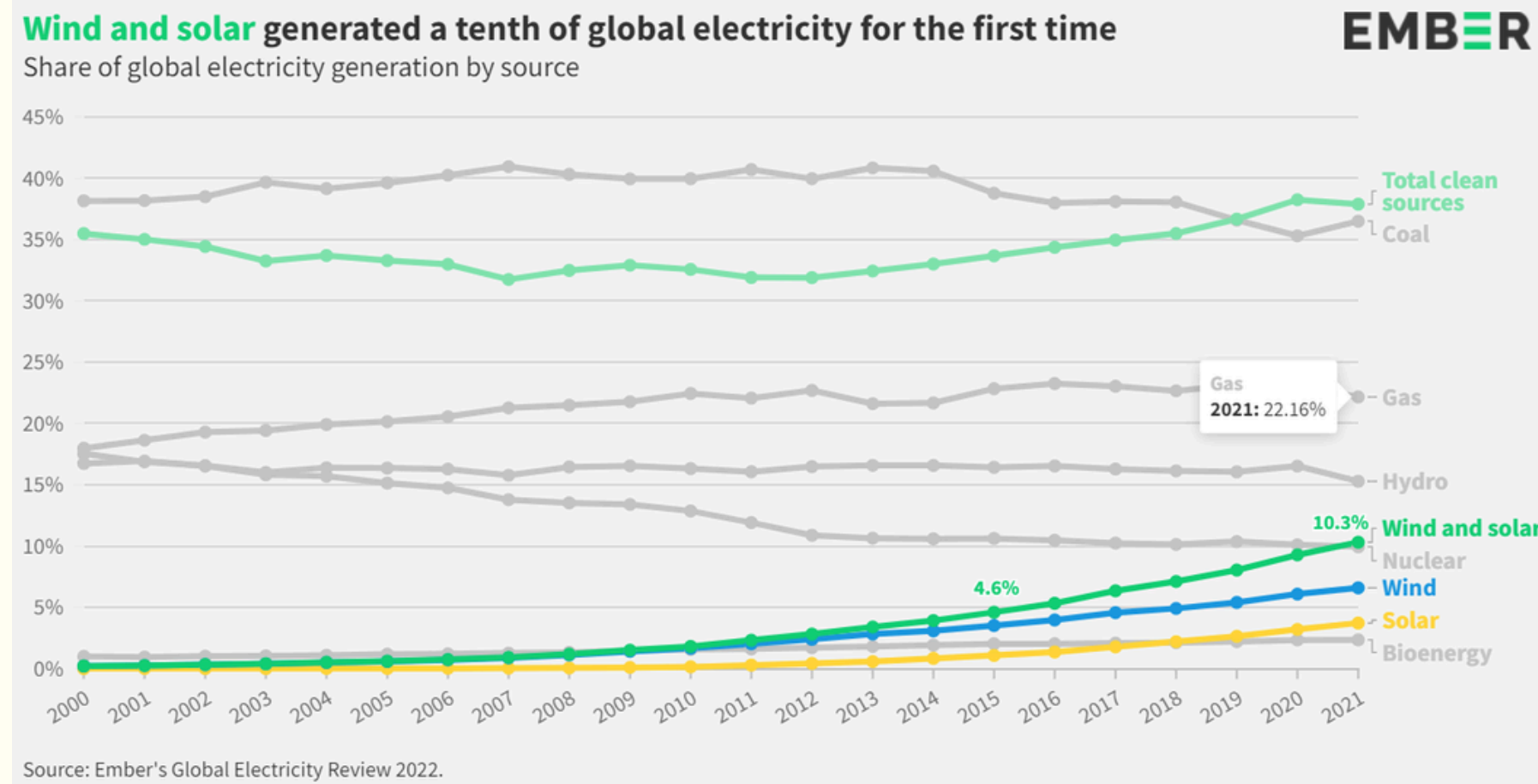
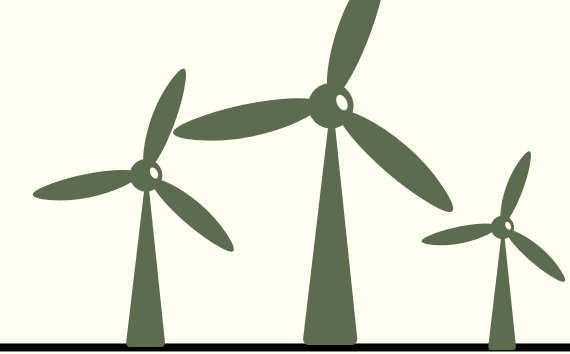


- **National Wind-Solar Hybrid Policy, 2018:**  
The main objective is to provide a framework for promotion of large grid connected wind-solar PV hybrid systems for optimal and efficient utilization of wind and solar resources, transmission infrastructure and land.
- **National Offshore Wind Energy Policy:**  
Objective is to develop offshore wind energy in the Indian Exclusive Economic Zone (EEZ) along the Indian coastline of 7600 km.

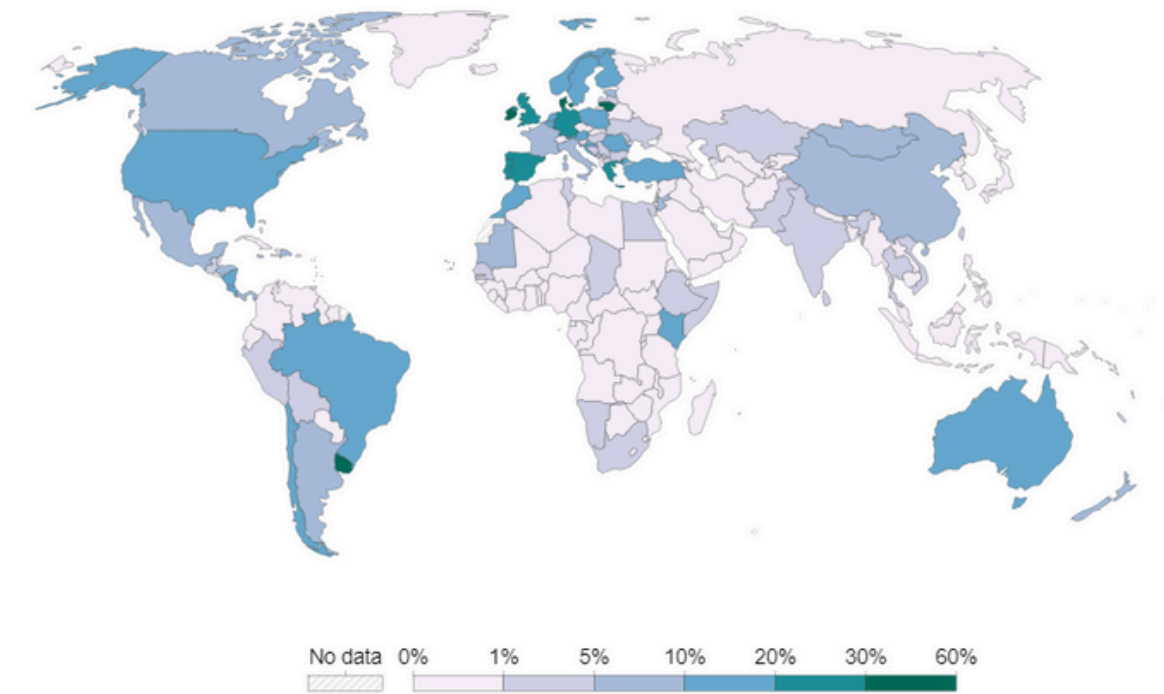


# CURRENT SITUATION

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Share of electricity production from wind, 2022



Source: Ember's Yearly Electricity Data; Ember's European Electricity Review; Energy Institute Statistical Review of World Energy  
OurWorldInData.org/energy • CC BY

- According to the International Energy Agency (IEA), wind power accounted for about **6% of global electricity generation** in 2020. This contribution has been increasing steadily over the past decade as countries invest in expanding their wind energy capacity.

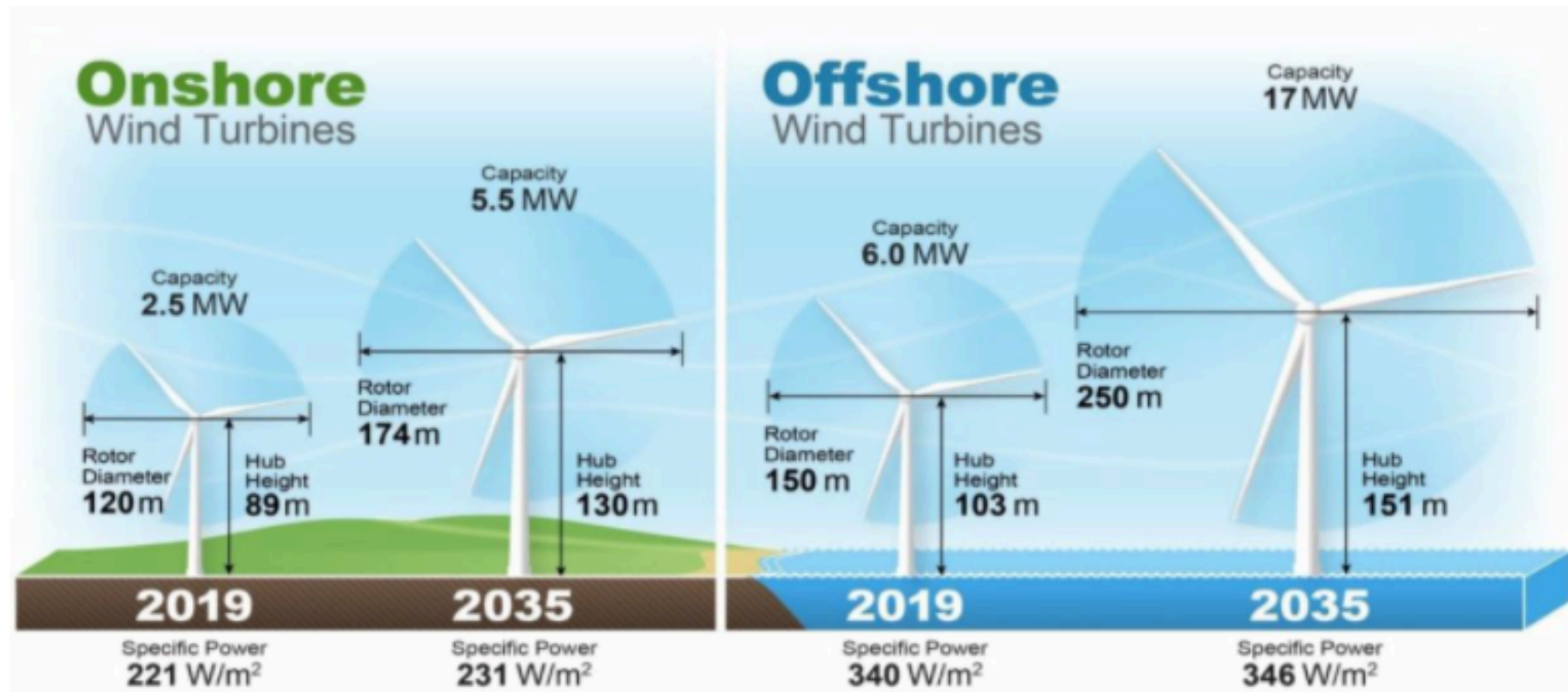
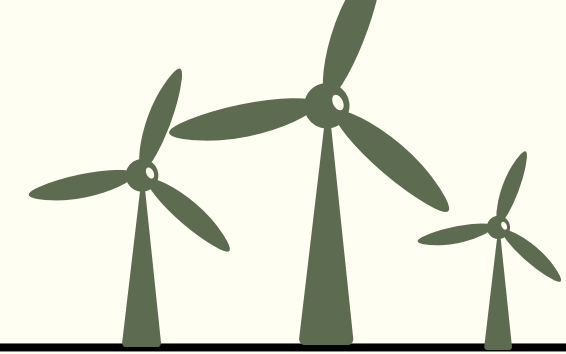
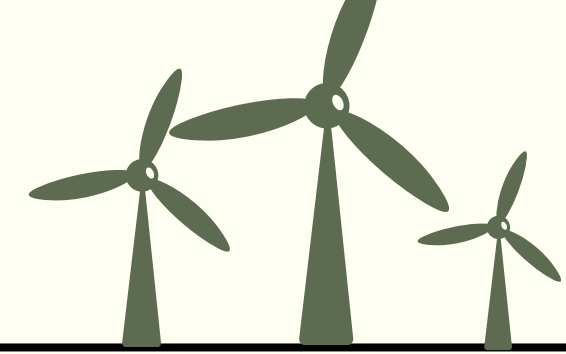


Figure 3. Experts anticipate significant growth in onshore and offshore turbine size

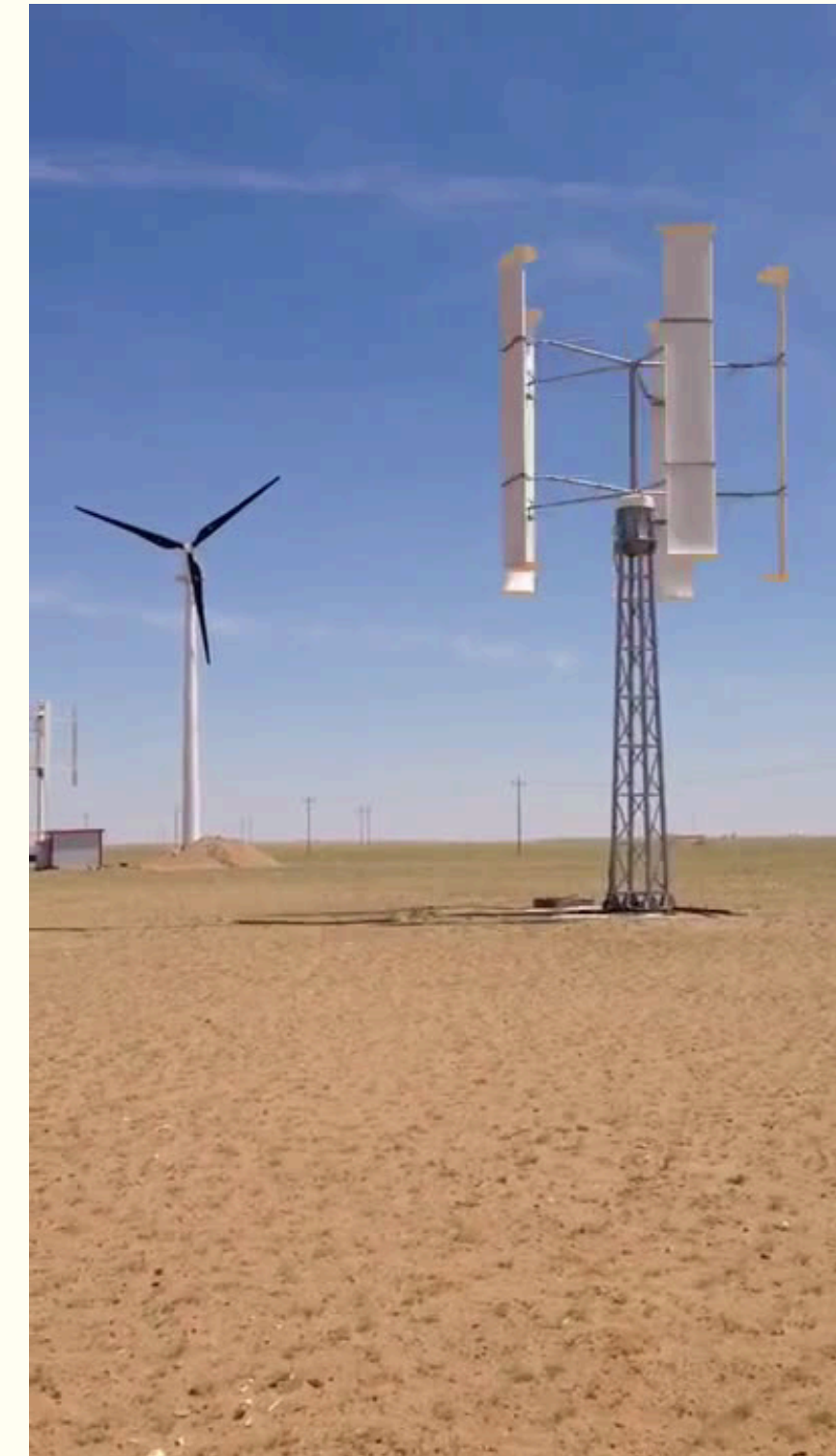
- India has established infrastructure for onshore wind farms but is relatively new to offshore wind energy.
- Ministry of New and Renewable Energy (MNRE) set a medium-term offshore target of **5 GW** by **2022** and a long-term target of **30 GW** by **2030**.
- **Gujarat** and **Tamil Nadu** identified as initial states for establishing the first offshore wind energy farms based on preliminary reports.





It's helium filled and  
**provides electricity** for  
families living off the grid

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*Thank You*